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AN EVALUATION OF COMPUTERIZED TESTS AS PREDICTORS OF JOB PERFORMANCE: II. DIFFERENTIAL VALIDITY FOR GLOBAL AND JOB ELEMENT CRITERIA

Charles H. Cory

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This report, the second of two, presents data concerning the validity of a set of experimental computerized and paper-and-pencil tests for measures of on-job performance on global and job elements. It reports on the usefulness of 30 experimental and operational variables for predicting marks on 42 job elements and on a global criterion for Electrician's Mate, Personnelman, Sonar Technician, and Apprenticeship rating groups.

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20. ABSTRACT (cont'd)

About 10 percent of the zero-order validities of experimental tests were statistically significant, with most of the significant validities being for the Sonar Technician rating. Most experimental tests with significant validities were computer-administered. Experimental variables substantially enhanced the predictive accuracy of the operational battery with the most useful increments being for the Sonar Technician rating.

There was little or no evidence of consistency of the job element characteristics across ratings. The job elements which were highly predictable were those which were important and central to the duties of particular ratings. For the Technical ratings, the most effective predictors of job element marks were experimental tests, with the best such tests being computer-administered. Use of Time Required and Importance ratings as moderators for prediction of global marks from the marks for job elements did not result in any practical increase in validity coefficients. Generally, low correlations were found between empirically-derived estimates of importance of personal attributes for particular job elements and similar estimates based on the judgments of personnel experts. Synthetic validity was generally not as accurate as multiple regression for predicting job performance.

FOREWORD

This study, the second of two, was performed under Task Area RR042-04-01 and Work Unit Number NR 150-335 (Job Element Approach to Validation of Perceptual Measures). It was supported by Personnel Training Research Programs of the Office of Naval Research.

The extensive assistance of other commands in carrying out this research is gratefully acknowledged. This command is particularly grateful to the Service School Command, San Diego, and the Recruit Training Center, San Diego, for releasing personnel for the 4 hours required for administering the experimental tests. Personnel from the Service School Command were very helpful in reviewing job element descriptions from the Position Analysis Questionnaire for wording and content.

J. J. CLARKIN
Commanding Officer

SUMMARY

Problem

To investigate computer-administered tests as a means of improving predictability of on-job performance, a set of computerized and paper-and-pencil tests measuring five job-relevant personal attributes were developed. These attributes are: (1) Short-term Memory, (2) Perceptual Speed, (3) Perceptual Closure, (4) Movement Detection, and (5) Dealing with Concepts/Information. This report, the second of two, presents data from several related studies concerning the validity and job-related characteristics of the experimental battery.

Approach

Questionnaires mailed out 9 to 10 months after the original test administration were used to collect supervisory ratings of on-job performance of research subjects. The usefulness of 34 experimental and operational variables for predicting both global performance and performance on 42 individual job elements was investigated for personnel in the Electrician's Mate, Personnelman, Sonar Technician, and Apprenticeship rating groups. Correlational and multiple-regression analyses were carried out.

The study's objectives are listed below:

1. To compare validities of the experimental variables with similar validities for operational classification tests.

2. To determine the consistency of predictive relationships of tests for job elements across ratings.

3. To test the knowledgeability of personnel experts concerning the relative importance of particular personal attributes for the performance of particular job elements.

4. To determine the usefulness of ratings of importance and percentage of time spent on job elements as moderator variables for predicting global performance marks from job element marks.

5. To compare the predictive accuracy of synthetic validity with the widely used stepwise multiple-regression technique.

Findings and Conclusions

1. About 10 percent of the zero-order validities of experimental tests were statistically significant, with most of the significant validities being for Sonar Technician. No experimental test was significant for a personal attribute in more than one rating. Most experimental tests with significant validities were computer-administered.

2. For all three Technical ratings, selected experimental tests substantially enhanced the predictability of the operational battery. Of the increases in the shrunken multiple-regression coefficients, that for Sonar Technician appeared to be operationally the most useful.

3. Of the five attributes, those for which computerized measurement would be the most useful for improving predictability, and would add the most to the predictability of on-job performance, were Movement Detection and Dealing with Concepts/Information.

4. There was little or no evidence of consistency of job element characteristics across ratings. The variables having significant zero-order validities for a job element in one rating, in general, did not have significant validities for the same element in other ratings.

5. The job elements which were highly predictable were those which were important and central to the duties of particular ratings. Thus, for Personnelman, the highly predictable job elements involved skills in writing, verbal communication, influencing others, and communicating routine information. For Sonar Technicians, skills with visual displays were highly predictable.

6. For Technical ratings, the most effective predictors of job element marks were experimental tests, with the best such tests being computer-administered. For the Apprenticeship group, the most effective predictors were operational tests.

7. In the Technical ratings, slight increases in accuracy of predicting global from job element marks were associated with using Time Required and Importance ratings as moderators. However, the increases appeared to be a result of capitalization on chance relationships and were not of practical importance.

8. Generally low correlations were found between empirically-derived estimates of importance of personal attributes for particular job elements and similar estimates based on the judgments of personnel experts. These findings imply that personnel experts cannot, in the abstract, make accurate determinations of attribute requirements for job elements.

9. Synthetic validity was generally not as accurate as multiple regression for predicting job performance.

Recommendations

1. Because measures of Closure had significant validities for job performance in all four ratings/rating groups, and had both positive and negative beta weights, a Closure test would be highly suitable for a battery designed to predict on-job performance. Measures of Closure should be added to any classification battery designed to predict the on-job performance of Navy enlisted personnel. (p. 10)

2. Skills in processing and interpretation of visual information, in addition to those measured by the operational tests, appear to be important for the on-job performance of Sonar Technicians. Measurement of these skills by experimental variables in the present research resulted in increases in predictability substantial enough to provide practical improvements in the selection of Sonar Technicians. However, before these experimental tests can be used operationally, the study must be replicated for at least 100, and preferably 200, Sonar Technician personnel. In addition, testing should be broadened to include personnel in other ratings requiring substantial processing of visual information from consoles or scopes (such as Operations Specialist). (pp. 9-11, 14, 16)

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BACKGROUND AND PURPOSE

Computerized testing equipment, in addition to its capabilities for adaptive testing (Cleary, Linn, & Rock, 1968; Wood, 1974; see especially Weiss & Betz, 1973), is promising as a means of increasing the scope of measurement. Such equipment permits exact determination of stimuli exposure times, control of moving stimuli, exact control of the sequence of stimuli presentation, successive modification of stimuli components, determination of response latencies, and sophisticated classification and scoring of responses. Since these characteristics are not available for paper-and-pencil tests, the use of computer-administered tests may substantially increase the number of abilities which can be used to predict personnel performance on the job.

This is the second report on a study which involved the development and validation of a set of computer-administered tests of position-relevant personal abilities or attributes. These attributes are: (1) Short-term Memory, (2) Perceptual Speed, (3) Perceptual Closure, (4) Movement Detection, and (5) Dealing with Concepts/ Information. The initial report (Cory, 1974) described the study rationale and the interrelationships of the computerized and non-computerized (paper-and-pencil) tests designed to measure the same abilities.

The present report has the following objectives:

1. To compare the validities of the experimental variables for global job performance with similar validities for operational classification tests.

2. To determine the consistency of predictive relationships of tests for job elements across ratings--that is, the extent to which performance on a job element was predicted by the same variables from rating to rating.

3. To test the knowledgeability of personnel experts concerning the relative importance of particular personal attributes for performing particular job elements.

4. To compare the predictive accuracy of the synthetic-validity technique with the widely used stepwise multiple-regression technique.

5. To determine the usefulness of ratings of importance and percentage of time spent on job elements as moderator variables for predicting global performance marks from job element marks.

PROCEDURE

Sample

For the previous stage of this research, a battery of 17 experimental tests (eight computerized and nine paper-and-pencil) was developed for experimental administration in conjunction with nine operational tests which are routinely given to Navy enlisted personnel. The experimental tests were administered during May and June of 1972, to 385 enlisted personnel at the Naval Training Center (NTC), San Diego. Subjects were either in their first 2 weeks of "A" school training (at the Service School Command) for rating as (1) Electrician's Mate (EM), (2)Personnelman (PN), or (3) Sonar Technician (ST), or in their final week of recruit training. Subjects in the latter category were limited to the upper 50 percent of the ability distribution for Navy enlisted personnel, and thus were comparable in general mental ability to those who had received "A" school assignments. As it turned out, most of the personnel in the group were assigned to general apprenticeship ratings rather than to "A" school training. For purposes of this report, they were classified as an Undifferentiated Apprenticeship (UA) group.

It has been suggested that supervisory marks based on job elements would provide more reliable and valid measures of performance than the commonly used global marks (Lawshe, 1952; Guion, 1965; Mecham & McCormick, 1969). Thus, for the present report, about 10 months after the experimental testing (after subjects had served in the fleet for several months), a mailout questionnaire was used to collect supervisory ratings covering both global and job element aspects of on-job performance. The 22-9 subjects for whom supervisory marks were returned were included in the analyses reported.

Variables

The variables used were experimental (computerized and paper-and-pencil) and operational test scores, selected biographical variables, and measures of job performance. Usually, test scores consisted of the number of correct answers. However, scores of tests having multiple-choice or true-false items were corrected for guessing.

Computerized Tests. The research was conducted on an IBM 1500 system with cathode ray tube display units and screens for film presentation, linked on-line to an IBM 1130 computer. A general description of the eight computerized experimental tests is included in Cory (1974). These tests, plus four more which were derived from special capabilities of computerized testing equipment, are listed

in Table 1. The names shown for a few of the variables are slightly different from those which have been previously reported (Cory, 1974). These changes were made to simplify comprehension and provide greater ease of reference. Also, in regard to derived tests, attention is directed to the fact that CLO-LAT differs from the WORD-LAT and FIG-LAT latency measures in that it measures time required to correctly identify an object rather than speed of response. Error rates did not influence the latter two latency scores.

Noncomputerized (paper-and-pencil) tests. The noncomputerized tests are also described in Cory (1974). They are listed in Table 2. Most of these tests are from the Educational Testing Service (ETS) factor reference battery (French, Ekstrom, & Price, 1963).

Biographical variables. Extracted from military records for use as biographical variables were Years of Education (YRED) and Year of Birth (YRBI).

Operational tests. The operational tests are also included in Table 2. Scores for these tests were extracted from the Enlisted Master Tape Record (EMTR). Scores for the Armed Forces Qualification Test (AFQT) are recorded as percentiles, and normally range from 10 to 99. The tests in the Navy enlisted classification battery (the last eight listed) are scored as Navy standard scores with means for a Navy population of approximately 50, and standard deviations of approximately 10.

Measures of job performance. An adaptation of the Position Analysis Questionnaire, a broad-based empirically-derived instrument which has been extensively used for job-classification research by E. J. McCormick and his associates (see McCormick, Jeanneret, & Mecham, 1972) was used to collect the ratings of job performance. To adapt the form, three committees from NTC, San Diego, consisting of chief petty officers in each of the three technical ratings, were convened and asked to select job elements in the Position Analysis Questionnaire which were present in the rating. During this step the wording of the job element was simplified, wherever possible. There was high agreement among members of each panel concerning the job elements which were appropriate to be included in the questionnaire.

TABLE 1

Computerized Experimental Tests

Test	Acronym	Content Area
Conventionally Derived		
Memory for Objects		Short-term recall of groups of pictures
Memory for Words		Short-term recall of groups of words
Memory for Numbers (Visual)		Short-term recall of groups of digits presented visually
Comparing Figures Machine-paced Self-paced		Comparison of objects for similarities and differences (a modified test of perceptual speed)
Recognizing Objects		Perceptual closure in the recognition of objects from fragmentary details
Memory for Patterns True-false Free response		Short-term memory for patterns formed by moving stimuli
Twelve Questions		Convergent reasoning using information presented in a "Twenty Questions" format
Password		Convergent reasoning on the basis of information presented in a "Password" format
Derived from Special Capabilities of Computerized Testing Equipment		
Latency of word memory responses	WORD-LAT	Total elapsed time in seconds before initiation of the subject's responses for Memory for Words
Latency of comparing figures responses	FIG-LAT	Total number of seconds which elapsed prior to initiation of subject's responses for Comparing Figures, self-paced
Total time required for identification of the objects in the computerized closure test	CLO-LAT	Total viewing time in seconds elapsing before all objects were identified
Magnitude of pattern error	PAT-ERR	A measure of the total extent to which the response pattern failed to duplicate the stimuli in Memory for Patterns, free response

TABLE 2

Noncomputerized Experimental and Operational Tests

Test	Acronym	Content Area
Experimental		
Memory for Numbers (Auditory)		Short-term recall of groups of digits
Object Number[a]		Short-term associative memory
Counting Numbers		Scanning rows of digits to identify specified numbers and count their frequencies
Gestalt Completion[a]		Perceptual closure in the recognition of objects from fragmentary details
Concealed Words[a]		Perceptual closure in the recognition of words from fragmentary details
Hidden Patterns[a]		Inspection of complex patterns to recognize simple target patterns
Drift Direction		Detection of the direction of minimal movements
Nonsense Syllogisms[a]		Syllogistic reasoning using nonsense words
Inference[a]		Evaluation of the correctness of inferences from given statements
Operational		
Armed Forces Qualification Test	AFQT	Vocabulary, arithmetic reasoning, spatial reasoning, and mechanical knowledge
General Classification Test	GCT	Word meanings and the ability to reason verbally
Arithmetic Reasoning Test	ARI	Quantitative aptitude, including mathematical reasoning and problem solving
Mechanical Test	MECH	Basic mechanical and electrical knowledge and mechanical principles
Clerical Test	CLER	Perceptual speed and accuracy
Sonar Pitch Memory Test	SONR	Ability to perceive and remember small differences in tonal pitches
Radio Code Aptitude Test	RADO	Ability to learn, remember, and use sound patterns as symbols
Electronic Technician Selection Test	ETST	Mathematics, science, electricity, and electronics
Shop Practices	SHOP	Knowledge of tools and shop equipment

[a]Factor reference test, Kit of Reference Tests of Cognitive Factors.

Items describing 42 job elements, together with estimates of percentage of time spent and importance of each element for global performance, were included in the questionnaire (see the Appendix). In addition, a rating of global performance was included. All ratings were carried out on a 5-point scale, with the choices designated: (1) lowest 5 percent, (2) next lowest 25 percent, (3) middle 40 percent, (4) next highest 25 percent, and (5) highest 5 percent.

Analysis

Zero-order validities for both global and job element criteria were computed separately for the four rating groups and were utilized to compute multiple-regression validities by means of a stepwise predictor selection technique.

Comparisons were concerned with the extent to which (1) the experimental variables could increment the predictive accuracy achievable from operational variables, and (2) predictive relationships were consistent for job elements across ratings. To test the accuracy of expert judgments concerning the validities of personal attributes for performance of job elements, the validities actually found were compared with predicted validities from Mecham and McCormick (1969). Comparisons of the synthetic-validity technique with multiple regression for a global criterion were carried out using a modification of the methodology used in a study by Guion (1965). The predictability of global performance marks from composites of job element marks was investigated using Time Spent and Importance marks as weighting variables in the following designs: (1) raw supervisory marks, (2) linear prediction, and (3) moderated prediction. The latter two methods were defined by Saunders (1956).

RESULTS

Incidence of questionnaire returns and final sample sizes of the rating groups are shown in Table 3. After preliminary analysis of the returned questionnaires, a 22-item subset of the job elements having the largest sample sizes was selected for analysis. These job elements, designated the common job elements, are shown in Table 4, together with their subsample sizes.

TABLE 3

Sample Sizes for Test Administration and Performance Follow-up

Rating Group	Test Administration	Performance Follow-up	Unavailable Because of Transfer, School Assignment, Discharge, etc.	Not Returned
Personnelman (PN)	61	54	4	3
Electrician's Mate (EM)	77	27	33	17
Sonar Technician (ST)	45	37	5	3
Recruits in upper half of the recruit distribution of ability (classified as Undifferentiated Apprenticeships) (UA)	172	111	44	17
TOTALS	355[a]	229	86	40

[a]Thirty cases were dropped because of incomplete experimental data, bad records, or rating misclassification.

TABLE 4

Sample Sizes for the 22 Most Common Job Elements

Job Element	Rating Group EM	PN	ST	UA
Using Written Materials	--	48	30	71
Using Pictorial Materials	20	--	32	--
Using Visual Displays	--	--	35	66
Using Spoken Verbal Communication	20	52	36	92
Using Nonverbal Sounds	--	--	31	--
Analyzing Information	20	--	--	--
Compiling Data	--	49	--	--
Manual Control, Nonprecision Tools	27	--	--	80
Manual Control, Precision Tools	23	--	--	--
Operating Keyboard Devices	--	53	--	--
Adjusting Machines/Equipment	23	--	29	--
Assembling-Disassembling	23	--	--	--
Hand and Arm Manipulation/Coordination	22	--	--	--
Hand and Ear Coordination	--	--	31	--
Persuading/Influencing Others	--	40	--	--
Exchanging Routine Information	--	51	--	69
Unusually Good Precision	--	--	29	69
Attention to Details, Completing Work	25	51	36	102
Vigilance, Continually Changing Details	20	--	--	--
Coping with Time Pressures	22	49	--	78
Working with Distractions	--	48	--	84
Keeping up-to-date	--	52	30	86

Prediction of Global Criteria

Zero-order correlations. Zero-order correlations of the experimental variables with supervisors' ratings of global job performance are shown in Table 5. Nine of the 92 validity coefficients were statistically significant (10percent), five of which were for computerized tests. No experimental test was significant for more than one rating. Most of the significant validities were for STs, with fewer numbers of significant validities for EMs, PNs, and UAs.

In comparison, five of 36 validities of the operational tests were statistically significant (Table 6), three of which were for the UA group. Thus, the operational battery was best for predicting global performance in apprenticeship ratings, whereas the experimental battery was more useful for predicting performance in technical ratings, and was particularly good for predicting the performance of STs.

The coefficients suggest that, of the five attributes, the most promising for computerized measurement are Movement Detection and Dealing with Concepts/Information.

Multiple correlations. Multiple regression statistics for optimal sets of the operational and experimental variables are shown in Tables 7 through 10. The optimum batteries were determined by means of a predictor selection technique using the accretion method. Predictor selection was terminated by reference to a conservative decision rule.[1] F ratios were used to determine the statistical significance of the regressions.

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[1]The following termination criteria were used:

1. To be added to the battery, a variable must increase not only the multiple-correlation coefficient, but also the estimated cross-validated correlation coefficient.

2. In general, variables added to the battery must have alpha values significant at $p < .05$. However, the alpha value of a variable could be in the range $.05 < p < .10$, provided that the next variable added to the battery was significant at $p < .05$ and the alpha value of the previous variable dropped to $p < .05$ on the new selection step. In other words, predictor selection for the battery was stopped at the first step for which a hypothesis of no increase in R could not confidently be rejected at $p < .05$.

TABLE 5

Zero-order Validities of Experimental Variables for Global Performance

Predictor	Rating Group: EM (N = 27)	PN (N = 54)	ST (N = 37)	UA (N = 111)
Short-term Memory				
Object Number	-.26	.13	-.03	-.01
Memory for Objects[c]	-.16	-.03	-.05	-.07
Memory for Words[c]	-.33	.20	.13	.01
Memory for Numbers (Visual)[c]	-.15	.20	.38*	-.01
Memory for Numbers (Auditory)	-.15	.17	.22	.08
Perceptual Speed				
Counting Numbers	.03	.04	.42*	.06
Comparing Figures, Machine-paced[c]	.02	-.10	.07	-.06
Comparing Figures, Self-paced[c]	.06	.07	.21	.08
Closure				
Gestalt Completion	-.28	-.26*	.28	.06
Concealed Words	-.37*	-.14	.13	-.10
Hidden Patterns	-.04	.23	.33*	.11
Recognizing Objects[c]	-.11	-.06	.25	-.05
Movement Detection				
Drift Direction	-.29	.07	.02	.06
Memory for Patterns, True-false[c]	.15	-.07	.42*	.07
Memory for Patterns, Free Response[c]	.19	.21	.23	.19*
Dealing with Concepts/Information				
Nonsense Syllogisms	-.30	.01	.30	-.06
Inference	.18	.19	.00	.13
Twelve Questions[c]	-.20	.28*	.21	.11
Password[c]	.08	.13	.33*	.04
Special Variables				
WORD-LAT[c]	-.24	-.06	-.05	-.11
CLO-LAT[c]	.05	.02	-.24	-.11
FIG-LAT[c]	-.04	.00	.02	.04
PAT-ERR[c]	-.24	-.17	-.26	-.13

*Significant at $p < .05$.

[c]Computer-administered test

TABLE 6

Zero-order Validities of Operational Variables for Global Performance

Predictor	Rating Group			
	EM (N = 21)	PN (N = 31)[a]	ST (N = 35)	UA (N = 109)[a]
Paper-and-Pencil Tests				
AFQT	-.09	.15	-.12	.13
GCT	.01	.24	.11	.07
ARI	-.20	.10	.38*	.25**
MECH	.04	.23	-.04	-.12
CLER	.21	-.15	.11	.19*
SONR	-.08	.15	-.08	-.03
RADO	-.06	.11	.15	.15
ETST	.16	.31	-.09	.33**
SHOP	.20	.38*	-.21	.17
Biographical Variables				
YRBI	-.12	.06	.01	-.11
YRED	.11	.05	-.02	.22*

[a]Complete data were not available for some of the tests.

*Significant at $p < .05$.
**Significant at $p < .01$.

TABLE 7

Optimal Predictive Composites for Global Performance of Electrician's Mates

Predictor Set	R: Weight Determination	R: Expected Cross-validation	Predictor	Beta Weight in Final Composite	N
Operational Classification Test Scores	.21	.00	CLER		27
Complete Set of Experimental and Operational Variables	.37	.00	Concealed Word	-.40	27
	.49	.20	CLER	.39	
	.58	.28	Drift Direction	-.28	
	.65	.34	PAT-ERR	-.50	
	.71	.40	Memory for Words	-.40	
	.78	.53	YRBI	-.36	

TABLE 8

Optimal Predictive Composites for Global Performance of Personnelmen

Predictor Set	R: Weight Determination	R: Expected Cross-validation	Predictor	Beta Weight in Final Composite	N
Operational Classification Test Scores	.38	.12	SHOP	.38	30
Complete Set of Experimental and Operational Variables	.38	.12	SHOP	.22	30
	.47	.20	Gestalt Completion	-1.19	
	.64	.46	GCT	1.40	
	.71	.52	FIG-LAT	.69	
	.80	.65	WORD-LAT	- .40	
	.86	.74	Memory for Patterns, True-false	.37	

TABLE 9

Optimal Predictive Composites for Global Performance of Sonar Technicians

Predictor Set	R		Predictor	Beta Weight in Final Composite	N
	Weight Determination	Expected Cross-validation			
Operational Classification Test Scores	.38	.22	ARI	.38	37
Complete Set of Experimental and Operational Variables	.42	.28	Counting Numbers	.33	37
	.54	.40	Memory for Patterns, True-false	.32	
	.61	.46	Nonsense Syllogisms	.29	
	.66	.50	Recognizing Objects	.33	
	.73	.58	Gestalt Completion	.32	

TABLE 10

Optimal Predictive Composites for Global Performance
of the Apprenticeship Group

Predictor Set	R		Predictor	Beta Weight in Final Composite	N
	Weight Determination	Expected Cross-validation			
Operational Classification Test Scores	.33	.28	ETST	.33	111
Complete Set of Experimental and Operational Variables	.33	.28	ETST	.33	111
	.37	.29	CLER	.21	
	.41	.32	Concealed Word	-.19	

Predictability of the operational battery was quite low--barely significant for most ratings--and validities were lower for the technical ratings than for UAs. On the other hand, quite high correlations were computed for the combined experimental and operational battery, particularly for the technical ratings. Increases in the estimated cross-validation coefficients of the complete set over those of the operational set were .53, .62, and .36 for the EM, PN, and ST ratings, respectively. Although none of the zero-order validities of the special variables were statistically significant, several of them served to increment the multiple correlations.

The better EMs were characterized by good perceptual speed, greater age, and poor closure, perception of movement, and memory skills. Distinguishing characteristics of the better PNs tended to be good technical knowledge, verbal ability, memory, and speed of recall of words, and poor closure and speed of recall of figural stimuli. Good STs generally had superior skills in perceptual speed, movement detection, closure, and dealing with concepts/information. The better UAs had relatively good technical knowledge and perceptual speed, and relatively poor closure skills.

Since the sample sizes for all three technical ratings were small, these findings should be interpreted cautiously. Of the several variables in the predictor composites which had negative beta weights, three were measures of perceptual closure, one was a measure of memory, and another three (PAT-ERR, YRBI, and WORD-LAT) resulted from directional artifacts of the scaling. Thus, if PAT-ERR were redefined as accuracy, year of birth as age in years, and WORD-LAT as speed of response, the scales would be reversed and the negative weights would become positive.

Prediction of Performance on Job Elements

Since information concerning the predictability of job elements would be useful for the development of new tests and selection batteries, the validities of the predictors were computed for job elements. These were examined critically for (1) evidence of statistically significant predictability, and (2) the consistency of the validities across ratings.

Zero-order correlations. The significant validities of operational and experimental variables for the 12 most predictable common job elements are shown in Tables 11 and 12, respectively.

TABLE 11

Significant Zero-order Validities of the Operational Variables for 12 Common Job Elements

Predictor Variable	Rating	Written Materials	Pictorial Materials	Visual Display	Verbal Communi-cation	Non-Precision Tools	Adjusting Equipment	Influencing Others	Routine Infor-mation	Good Precision	Attention to Details	Working with Distractions	Up-to-Date
		Job Element											
AFQT	ST			-33*		--		--	--			--	
GCT	PN		--	--	50*	--	--			--			36*
	UA		--		22*		--	--	27*				
ARI	ST	49**				--		--	--			--	
	UA		--		24*		--	--	41*	27*	23*		
MECH	PN		--	--		--	--	55**		--	38*		
CLER	UA	25*	--		20*		--	--		29*	30**		26*
SOMR	PN		--	--		--	--			--			37*
	UA	-26*	--				--	--					-26*
RADO	EM	--		--				--	--	--	-44*	--	--
	ST	36*	41*		33*	--		--	--		37*	--	39*
	UA		--		22*		--	--					
ETST	UA		--				--	--	28*				24*
SHOP	PN		--	--	45*	--	--	42*		--			
YRED	UA		--		21*	22*	--	--	34**	31**	26**		
		Cell Ns											
	EM		15		16	21	18				19		
	PN	26		29	27			20	28		29	27	31
	ST	29	30	33	34		27			27	34		28
	UA	69		66	90	79			67	67	100		84

Note. Decimal points were omitted from validity coefficients.

Coefficients significant at $p < .05$ and $p < .01$ have been identified by single and double asterisks, respectively.

A blank cell indicates nonsignificant validity.

A double hyphen (--) indicates missing data.

Table 12

Significant Zero-order Validities of the Experimental Variables for 12 Common Job Elements

Predictor Variable	Rating	Job Element: Written Materials	Pictorial Materials	Visual Display	Verbal Communication	Non-Precision Tools	Adjusting Equipment	Influencing Others	Routine Information	Good Precision	Attention to Details	Working with Distractions	Up-to-Date
Obj. No.	EM	--		--				--	--	--	-38*	--	--
Mem. Obj.	EM	--		--			-53**	--	--	--		--	--
	UA		--			-24*	--	--				-24*	
Mem. Words	ST	42*				--		--	--			--	
	PN	29*	--	--		--	--			--			
Mem. for Nos. (V)	PN	33*	--	--	48**	--	--			--			33*
	ST	40*				--		--	--			--	
Mem. for Nos. (A)	PN	29*	--	--	42**	--	--			--			
	EM	--		--				--	--	--	-42*	--	--
Counting Numbers	UA		--				--	--			26**		
	ST					--		--	--			--	39*
Comp. Figs., Machine-paced	UA	25*	--		20*		--	--		29*	30**		26*
	PN		--	--		--	--			--			44**
Gest. Comp.	EM	--		--		-40*		--	--	--	-42*	--	--
Hidden Patterns	EM	--		--		-36*		--	--			--	--
	PN		--	--	30**	--	--	32**		--			34*
	ST		39*			--		--	--			--	35*
Rec. Objs.	ST	45*				--		--	--			--	
Mem. for Pats., Free Response	ST	40*				--		--	--			--	38*
	UA		--				--	--			24*		28**
	PN		--	--		--	--			--		36*	25*
Nonsense Syls.	EM	--		--				--	--	--	-38*	--	
Inference	PN	37*	--	--	42**	--	--	49**	37*	--			29*
Twelve Questions	PN	42**	--	--	44**	--	--	36*	55**	--		42**	31*
	ST					--		--	--			--	37*
Password	PN	33*	--	--	43*	--	--			--	30*		
	ST					--	46*	--	--			--	
WORD-LAT	EM	--		--			-41*	--	--	--		--	--
CLO-LAT	ST		-47**	-44**		--		--	--			--	-37*
PAT-ERR	UA		--				--	--			-21*		-23*
	PN		--	--		--	--			--		-37*	
FIG-LAT	PN		--	--		--	--	-36*		--			
	ST			34*		--		--	--			--	
	UA		--				--	--		31**			
Cell Ns													
	EM		20		20	27	23				25		
	PN	45			48			37	47		47	44	48
	ST	29	31	34	36		29			29	36		30
	UA	71		66	92	80			69	69	102	84	86

Note. Decimal points were omitted from the validity coefficients.

Coefficients significant at $p < .05$ and $p < .01$ have been identified by single and double asterisks, respectively.

A blank indicates nonsignificant validity.

A double hyphen (--) indicates missing data.

In these tables, cells not containing common job elements for a rating are shown with double hyphens, cells having nonsignificant validities have been left blank, and predictor variables with no statistically significant _r_'s have been omitted.

The operational tests were primarily predictors of writing and verbal communication skills and to a lesser extent were significant predictors of precision and accuracy. In both Table 11 and Table 12 the large number of significant validities for Attention to Details and Keeping up-to-date together with the apparent lack of patterns across ratings relating tests to these job elements suggest that these elements served as generalized, nonspecific positive evaluation categories.

Generally, operational variables were less effective for predicting performance on job elements in technical than in apprenticeship ratings. For the three technical ratings, a total of only 16 correlations were statistically significant, compared with 21 significant correlations for UAs. However, the significant validities of operational variables rather frequently appear not to reflect underlying mental abilities or constructs as they are commonly defined (Guilford, 1967, Messick, 1973). Thus, ARI, and SHOP were found to be significant predictors of verbal skills; MECH and SHOP were indicators of ability to influence others; RADO significantly predicted ability in verbal communication and in interpretation of pictorial materials; and ETST was an indicator of ability to communicate routine information.

The paucity of distinctive predictor-job element relationships for operational variables may be related to the lack of accurate dimensional definition in the selection and classification tests, which has been pointed out previously (Cory, 1971, pp.9-12). Thus, the specific operational test-job element validities which were statistically significant seem best explained as resulting from a low to moderate correlation of "g" (the primary content of the classification battery) (Cory, 1971, 1974) with job performance, together with chance variations in the sample subgroups.

Predictor-job element construct validities were more logically defined for the experimental tests (Table 12). Thus, short-term memory variables tended to predict Writing and Verbal Communication for PNs; Dealing with Concepts/Information variables tended to predict Writing and Verbal Communication, Influencing Others, and Communicating Routine Information for PNs; and the special variables predicted Visual Display for STs.

There was considerable variation across ratings in the types of tests which were significantly related to performance on the job elements. For instance: for Written Materials the significant predictors for PNs included primarily memory and verbal reasoning variables; for STs memory

and perceptual variables; and for UAs perceptual variables. For Verbal Communication for PNs significant predictors were academic learnings, perceptual and reasoning skills, and memory; and for UAs academic learnings, perceptual skills and years of education. Significant predictors for Non-precision Tools for EMs included closure measures and for UAs, memory and years of education. For Adjusting Equipment, EMs required memory and speed and STs required verbal reasoning. These and other differences across ratings in the content of tests having significant validities indicate that the same job element frequently varied considerably from one rating to another.

Multiple correlations. Data for the multiple correlations of the most predictive three-variable batteries, shown in Tables 13 and 14, also indicated that experimental tests were better predictors of job performance than were operational tests. Sixty-six of the variables entering into these multiple regressions were experimental variables--more than three times the 21 operational selections. Biographical variables were selected nine times and AFQT, three times.

Once again, predictors for a particular job element tended to differ considerably from one rating to another. Even when a variable was selected for the same job element in two different ratings, the beta weights frequently differed markedly (cf., Inference as a predictor for Written Materials for PNs and STs, and Gestalt Completion and CLO-LAT as predictors of Verbal Communication for EMs and STs).

Job elements were generally not as predictable as global performance. Of the ten Rs for job elements for UAs, eight were lower than the R for the global criterion. For the EMs, PNs, and STs, respectively, 5 of 11, 10 of 10, and 8 of 10 of the Rs for job elements were lower than that for global performance. The multiple correlations, as did the zero-order correlations, showed the operational battery to be more useful for UAs and the experimental battery, for the technical ratings.

Predicatability of Global Marks from Job Element Marks

Regressing the global job performance mark for a rating on marks for its common job elements will provide information on the job element dimensionality of the global mark. Thus, the extent to which each mark increments the shrunken R indicates the importance of performance on the job element for global performance.

Predictabilities of global performance from the job element marks are shown in Table 15. The maximum expected cross-validation R for global marks in each rating was fairly close to the reliability of global marks found in previous studies (Cory, 1975; and unpublished studies). The first predictor selected for each rating was a generalized measure of performance. For most ratings, performance on rather narrowly defined job elements incremented the predictability of the generalized variables. Although the variability of duty assignments of UAs was undoubtedly greater than that of a particular technical rating, the global marks of UAs were as predictable as those of other ratings.

TABLE 13

Optimal Predictive Composites for Marks of Job Elements
Common to Two or More Ratings

Criterion Element	EM: R Weight Developm.	EM: R Shrunken Cross-val.	EM: Variable Selected	EM: Beta Weight	PN: R Weight Developm.	PN: R Shrunken Cross-val.	PN: Variable Selected	PN: Beta Weight
Skill Using Written Materials					.37	.24	Inference[e]	.43
					.50	.38	Gestalt-Completion[e]	-.46
					.58	.46	Memory for Numbers (V)[e]	.33
Using Pictorial Materials	.44	.05	Recognizing Objects[e]	-.44				
Using Visual Displays								
Using Spoken Verbal Communication	.41	.00	WORD-LAT[e]	-.58	.48	.40	Memory for Numbers (A)[e]	.37
	.67	.49	Hidden Pattern[e]	-.62	.56	.46	Password[e]	.31
	.79	.64	CLO-LAT[e]	-.42				
Manual Control, Nonprecision Tools	.40	.15	Gestalt Completion[e]	-.24				
	.52	.27	SHOP	.45				
	.65	.45	GCT	-.44				
Adjusting Machines/ Equipment	.53	.37	Memory for Objects[e]	-.58				
	.69	.55	Recognizing Objects[e]	-.42				
	.76	.62	WORD-LAT[e]	-.33				
Exchanging Routine Information					.55	.47	12 Questions[e]	.63
					.60	.51	Memory for Patterns, True-false[e]	.29
					.66	.55	Concealed Word[e]	-.28
Unusually Good Precision								
Attention to Details Completing Work	.42	.18	Gestalt Completion[e]	-.37	.33	.18	YRBI	.50
	.58	.37	Memory for Numbers (A)[e]	-.40	.49	.33	12 Questions[e]	.44
	.68	.48	Nonsense Syllogisms[e]	-.35	.59	.39	RADO	.32
Coping with Time Pressure					.46	.31	SHOP	.89
	.55	.39	Recognizing Objects[e]	-.73	.61	.47	AFQT	-.64
	.79	.71	Gestalt Completion[e]	-.60	.72	.60	Object No.[e]	.43
Working with Distractions					.37	.25	PAT-ERR[e]	-.18
					.48	.32	12 Questions[e]	.48
					.58	.38	MECH	-.35
Keeping Up-to-Date					.34	.21	Hidden Patterns[e]	.34

TABLE 13 (continued)

Criterion Element	ST R Weight Developm.	ST Shrunken Cross-val.	ST Variable Selected	ST Beta Weight	UA R Weight Developm.	UA Shrunken Cross-val.	UA Variable Selected	UA Beta Weight
Skill Using Written Materials	.49	.35	ARI	.97	.26	.11	SONR	-.30
	.68	.57	AFQT	-.53	.36	.22	Comparing Figures[e]	.25
	.78	.68	Inference[e]	-.43				
Using Pictorial Materials	.48	.34	CLO-LAT[e]	-.52				
	.63	.51	RADO	.37				
	.72	.60	Password[e]	.35				
Using Visual Displays	.44	.31	CLO-LAT[e]	-.44	.23	.00	Counting Numbers[e]	.23
	.56	.42	Gestalt Completion[e]	.41				
	.64	.49	Memory for Numbers (V)[e]	.32				
Using Spoken Verbal Communication	.33	.06	RADO	.33	.24	.12	ARI	.24
Manual Control, Nonprecision Tools					.24	.10	Memory for Objects[e]	-.23
					.32	.17	YREL	.21
Adjusting Machines/ Equipment	.46	.30	Password[e]	.51				
	.62	.47	CLO-LAT[e]	-.41				
Exchanging Routine Information					.41	.35	ARI	.39
					.47	.39	YREL	.24
					.52	.43	Concealed Word[e]	-.23
Unusually Good Precision	.36	.00	AFQT	-.36	.31	.20	YREL	.28
					.42	.31	FIG-LAT[e]	.28
Attention to Details Completing Work	.37	.18	RADO	.37	.30	.23	CLER	.25
					.36	.27	YRED	.19
					.39	.29	Memory for Objects[e]	-.17
Coping with Time Pressure					.26	.13	YRED	.30
					.34	.21	Nonsense Syllogisms[e]	-.23
Working with Distractions					.24	.11	Memory for Objects[e]	-.28
					.35	.24	Memory for Numbers (V)[e]	.26
Keeping Up-to-date	.39	.16	Counting Numbers[e]	.35	.28	.19	Memory for Patterns, Free Response[e]	.36
	.51	.29	12 Questions[e]	.33	.43	.36	SONR	-.34

[e]Experimental variable.

TABLE 14

Optimal Predictive Composites for Marks of Common Job Elements Unique to One Rating

Criterion Element	EM: R Weight Developm.	EM: R Shrunken Cross-val.	EM: Variable Selected	EM: Beta Weight	PN: R Weight Developm.	PN: R Shrunken Cross-val.	PN: Variable Selected	PN: Beta Weight	ST: R Weight Developm.	ST: R Shrunken Cross-val.	ST: Variable Selected	ST: Beta Weight
Using Nonverbal Sounds									.39 .57 .67	.17 .42 .52	Object No.[e] Counting Numbers[e] ETST	-.48 .34 -.36
Analyzing Information	.51 .66 .76	.30 .46 .57	RADO CLER DDT[e]	-.51 .46 -.38								
Skill in Compiling Data					.35 .46 .54	.22 .33 .40	Object No.[e] Memory for Objects[e] Hidden Patterns[e]	.36 -.33 .29				
Manual Control, Precision Tools	.54 .64 .76	.39 .47 .61	Nonsense Syllogisms[e] Gestalt Completion[e] CLER	-.61 -.39 .41								
Skill Operating Keyboard Devices					.37 .50	.20 .35	12 Questions[e] YRBI	.48 .36				
Assembling-Disassembling Items	.47	.30	Memory for Objects[e]	-.47								
Hand-arm Manipulation, Coordination	.43 .58 .70	.12 .32 .48	Memory for Objects[e] 12 Questions[e] MECH	-.50 .38 .39								
Hand-ear Coordination									.40 .54 .62	.20 .37 .44	Memory for Patterns, True-false[e] CLO-LAT[e] ARI	.34 -.37 .31
Persuading/ Influencing Others					.49 .65 .78	.39 .55 .71	Inference[e] MECH Password[e]	.67 .62 -.60				
Vigilance, Continually Changing Details	.52 .63 .75	.31 .40 .55	YRBI 12 Questions[e] Recognizing Objects[e]	-.59 -.42 -.41								

[e]Experimental variable.

TABLE 15

Predictability of Global Performance Marks from Ratings
for the Common Job Elements

Rating	R: Weight Determination	R: Expected Cross-validation	Predictor	Beta Weight in Final Composite	N
Electrician's Mate	.70	.62	Coping with Time	.71	20
	.76	.65	Adj. Machines / Equip.	-1.02	
	.83	.72	Assembling, Disassembling	.73	
	.94	.88	Verbal Communication	.52	
Personnelman	.71	.68	Using Written Materials	.54	48
	.79	.76	Coping with Time	.38	
Sonar Technician	.70	.64	Keeping Up-to-date	.51	29
	.79	.74	Good Precision	.42	
Apprenticeship Group	.65	.63	Attention to Details	.22	71
	.77	.74	Using Written Materials	.46	
	.78	.75	Working with Distractions	.21	

Since about 40 percent of the variance of the global marks was not explainable from the job element marks, other factors could have influenced the global marks--either as independent effectors or as moderating variables. In this respect, two possibilities as moderators were: (1) amount of time spent on a job element, and (2) the relative importance of performance on the job element to performance on the total job. This is plausible because global marks probably reflect not only performance on the pertinent job elements, but also the importance of the individual elements for the total job.

The influence of supervisory ratings of these variables as possible moderators of global performance was investigated, using composite variables formed from weighted performance marks for the most predictive job elements (Table 15). The marks by supervisors for time spent, and for importance were used to weight the job element marks in accordance with three paradigms:

1. Linear prediction, as defined by Saunders (1956). For this method either the Time Spent or Importance marks corresponding to the Performance marks in Table 15 were used together with the Performance marks as predictors of global performance.

2. Moderated prediction, as defined by Saunders (ibid.). This method utilizes as predictor sets the appropriate job element marks in Table 15, either their Time Spent or Importance marks, and the cross products of all of these variables.

3. Weighting the Performance marks by Time Spent or Importance marks.

Because of the relatively small sample sizes, it was possible that increases in predictive accuracy which might be observed with moderator-variable techniques might result from over-fitting the regression line instead of tapping additional, reliable predictor/criterion covariance. Therefore, using the following decision rules two sizes of predictor batteries were selected:

1. Restricted predictor sets for moderated regression were limited to the number of variables that were selected for the unmoderated runs (shown in Table 15), i.e., four for EM, two for PN, etc.

2. Maximum sets were selected by means of the method for selecting predictor batteries for multiple regression described previously in this report.

Table 16 shows the shrunken Rs of optimal batteries formed by using Performance (P), Importance (I), and Time Spent (T) ratings as predictors. Column 8 of Table 16 shows the number of variables selected for unmoderated predictor batteries. The Rs from data sets formed for three different models are shown in columns 2 through 7.

The total numbers of variables selected for the moderated predictor sets were larger in all cases than the number selected for the unmoderated sets. Computing global marks as linear sums of the raw job element marks, weighted by the I or T marks, typically decreased the Rs, with the greatest decreases being associated with the T weights. For EMs, PNs, and STs, maximum sets of both the moderated techniques substantially increased the Rs computed from unmoderated regressions, with generally greater increases resulting from moderated rather than linear prediction. However, both the linear and the moderated increments largely disappeared for Restricted models. Weighting and moderated-variable techniques provided no substantial improvement in predicting global marks for UAs.

On balance, the moderated-variable techniques appear not to have improved the accuracy with which global marks could be predicted from marks for job elements.

Accuracy of Expert Judgments of Job Element Requirements

Judgments of personnel experts concerning the relative importance of attributes for jobs are usually the basis for the initial selection of tests for a battery. Thus, the battery's usefulness depends heavily on the quality of the judgments underlying it. Since it is well known that opinions are sometimes based on unsystematic observations and personal predilections, it is pertinent to investigate the accuracy of judgments of personnel experts concerning test validities. Median estimates by personnel experts of the importance of specific attributes for job performance of job elements were reported in previous research (Mecham & McCormick, 1969). The present study offered a unique opportunity to compare the accuracy of those estimates with the validities actually found. For this purpose, the median validity of experimental and operational tests designed to measure the same personal attribute (Short-term Memory, Perceptual Speed, Perceptual Closure, Movement Detection, or Dealing with Concepts/Information) were computed for all of the common job elements. The median validities were correlated with the median personal attribute-job element ratings computed by Mecham and McCormick (Table 17).

TABLE 16

Shrunken Cross-validation Coefficients for Optimal Batteries of P, PI, and PT Variables for the Most Predictive Job Elements for Each Rating

Rating	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Shrunken *R*							Number of Predictors Selected			Sample Size
	P	PI	PT	Linear (Maximum)	Linear (Restricted)	Moderated (Maximum)	Moderated (Restricted)	P and (Restricted)	Linear (Maximum)	Moderated (Maximum)	
EM	88	71*	46**	93	88	96**	90	4	6	6	27
PN	76	69	61	80	76	85	67	2	4	8	30
ST	74	80	72	81	78	95**	86*	2	6	9	37
UA	75	62*	60**	75	75	78	76	3	3	7	111

Note. Decimal points omitted from cross-validation coefficients.

*$p < .05$.
**$p < .01$.

TABLE 17

Predictive Validity of Median Personal Attribute-Job Element Marks from Mecham and McCormick

Personal Attribute	Directionality of *r*	Rating EM	PN	ST	UA	All Ratings
Movement Detection	Signed	47	-07	01	-06	-05
	Absolute value	-48	-33	-14	-09	-06
Dealing with Concepts/ Information	Signed	-25	67*	-32	41	25
	Absolute value	04	67*	-30	39	25
Closure	Signed	-06	-42	-20	53	04
	Absolute value	-40	37	-27	34	-08
Perceptual Speed	Signed	-41	-51	-57	05	-29
	Absolute value	-42	-24	-43	05	-19
Short-term Memory	Signed	31	46	43	42	45**
	Absolute value	-29	46	52	19	-01

Note. Decimal points omitted from coefficients.

*$p < .05$.
**$p < .01$.

Both signed and unsigned values of the validity coefficients were used to compute the *r*s in Table 17. The lower rows of Table 17, based on the unsigned values, provided statistics which were consistent with the phrasing in the questionnaire used by Mecham and McCormick (the experts were asked only for the magnitude of the relationships, not their directionality). Although, in general, the lower validities were those based on the unsigned values, the differences were not substantial. The following comments refer to the correlations of the signed values.

The coefficients varied substantially from rating to rating. The usefulness of Dealing with Concepts/Information was accurately estimated for PNs, but the estimates were wide of the mark for STs--actually having negative validities. On the other hand, the accuracy of estimates for Short-term Memory tended to be moderate and positive across ratings. The low values for Perceptual Speed were surprising in view of the extensive use of tests measuring this attribute. In general, the estimates by experts of job element/personal attribute relationships were not very accurate. Only two of the 25 correlations were statistically significant.

Whether or not personnel experts know the personal attribute requirements of job elements for positions in their specific organizations may still be an unsettled question. However, these data suggest that personnel experts do not accurately make such determinations in the abstract.

Comparisons of the Predictive Accuracy of Synthetic-validity and Multiple-regression Techniques

By focusing on the marks for the individual job elements, synthetic validity theoretically offers substantial increases in accuracy over multiple regression. For one thing, it adjusts estimates of job performance to allow for task differences among jobs. Second, by restricting the scope of the rating element, it should decrease the amount of halo effect in the marks.

The most promising study of the synthetic-validity technique published to date (Guion, 1965) minimized the influence of halo on ratings of job elements by providing for close personal supervision of the raters. Because the supervisory marks were collected by mail in the present study, similar supervision was not possible, nor was it desirable, from the Navy's standpoint. If a questionnaire technique were found to improve predictability of supervisory marks, it might be adaptable for operational use, whereas a technique requiring close supervision of the supervisory marking process probably would not be useful in the operational setting.

Because of the relatively small sample sizes, synthetic validity analysis was not carried out separately for each of the three technical ratings. Instead the data for EMs, PNs, and STs were combined to form a Technical group. Synthetic-validity coefficients were computed by means of the following procedure: (1) Personnel records sorted into Technical, UA, and Total Group samples, each randomly divided into Weight Determination and Alternate subsamples; (2) a double cross-validation design was used in which the weight determination equations were computed, then cross validated on their alternate

sample counterparts, and vice versa; (3) for each subsample, the set of job elements, predictive of global performance, was identified by a multiple-regression technique; (4) from additional multiple-regression runs, those job elements were predicted by sets limited to four or fewer variables; (5) equations for these sets were used to compute predicted $\underline{z}$ scores for the appropriate subsample, and the $\underline{z}$ scores were summed to arrive at estimated performances for the job elements; (6) these estimates, in turn, were summed to form total predicted scores which were ordered and split into highs and lows; and (7) these types of statistics were also computed by multiple regression, using global performance as the criterion. Two-by-two tables summarizing the synthetic-validity and multiple-regression statistics for the cross validations are shown in Table 18. The percentage of correct predictions is shown in the two right-hand columns of the table.

Clearly, synthetic validity did not result in more accurate predictions than the regular multiple-regression technique. For both the UA and the Total Group samples, the accuracy of synthetic validity was substantially lower than that of multiple regression. For the Technical samples, synthetic validity was about as good, overall, as multiple regression. Thus, synthetic validity does not appear to be promising as a technique for improving the predictability of job performance of Navy enlisted men.

A probable reason for these disappointing results is shown in Tables 19 and 20, which present the intercorrelations among the supervisory marks for the common job elements as they were defined for computing the synthetic-validity statistics. Despite the orthogonality implied for job elements from their factor-analytic origins, the performance marks were substantially intercorrelated. Communality estimates for these marks ranged from 30 to 60 and were about the same magnitude as the job element/global mark correlations. Thus, it is apparent that halo effect was not eliminated by using job element marks.

FINDINGS AND CONCLUSIONS

Prediction of Global Criteria

1. About 10 percent of the zero-order validities of experimental tests were statistically significant, most of which were for Sonar Technician. No experimental test was significant for more than one rating.

TABLE 18

Predictive Accuracy of the Synthetic-validity and Multiple-correlation Methods for the Technical, Apprenticeship, and Total Group Cross-validation Subsamples

Subsamples	Predicted Performance by Means of Synthetic Validity		Performance Rating	Predicted Performance by Multiple Regression		Percent of Improvement Over Chance	
	P to M	S		P to M	S	Synthetic Validity	Multiple Regression
			Apprenticeship				
W.D.	14	10	Superior	11	13	- 1.81	21.42
	17	14	Poor to Mediocre	21	11		
A	13	10	Superior	10	13	5.45	27.27
	19	13	Poor to Mediocre	22	10		
			Technical				
W.D.	10	12	Superior	12	10	32.20	18.64
	27	10	Poor to Mediocre	25	12		
A	10	13	Superior	9	14	28.81	38.98
	25	10	Poor to Mediocre	27	9		
			Total Group				
S.D.	29	17	Superior	28	18	- .86	2.60
	40	29	Poor to Mediocre	41	28		
A	25	21	Superior	23	23	11.5	19.29
	42	25	Poor to Mediocre	45	23		

TABLE 19

Intercorrelations Among Performance Marks for the Common Job Elements for the Apprenticeship Ratings

	1	2	3	4	5	6	7	8	9	10	M	SD	N	Estimated Communality	Global
1 Writing Mats.	--	46**	58**	49**	68**	64**	60**	57**	59**	70**	3.14	.99	71	59**	72**
2 Visual Display		--	31*	48**	31*	27*	23	17	00	38**	3.20	.79	66	30*	33**
3 Verb. Comm.			--	51**	52**	66**	65**	50**	63**	61**	3.15	.98	92	56**	52**
4 Nonprec. Tools				--	52**	51**	49**	45**	38**	51**	3.29	.84	80	48**	51**
5 Routine Info.					--	74**	60**	61**	67**	59**	3.19	.99	69	59**	60**
6 Good Prec.						--	88**	60**	65**	64**	3.26	.88	69	59**	59**
7 Attention Details							--	65**	70**	69**	3.14	.98	102	55**	65**
8 Cope Time								--	58**	61**	3.23	.77	78	60**	54**
9 Work Dist.									--	60**	3.22	.90	84	59	64**
10 Up-to-date										--	3.09	.92	86	59	66**

Note. Decimal points have been omitted from correlation coefficients.

*$p < .05$.
**$p < .01$.

TABLE 20

Intercorrelations Among Performance Marks for the Common
Job Elements for Technical Ratings

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	M	SD	N	Estimated Communality	Global
1 Written Mats.	—	52**	46**	51**	46**	60**	48**	39**	33**	61**	53**	40**	56**	82**	42**	62**	73**	57**	68**	52**	51**	58**	3.14	.75	88	54**	58**
2 Pict. Mats.		—	49**	41**	42**	53**	44**	30*	36**	-01	60**	58**	33*	27*	59**	56**	32*	47**	46**	28*	40**	67**	3.17	.78	58	43**	48**
3 Visual Disp.			—	27	51**	58**	18	43**	28*	-78**	55**	41**	32*	60**	43**	33*	44**	31*	42**	38**	19*	40**	3.37	.69	52	42**	46**
4 Verb. Comm.				—	56**	37**	36**	36**	46**	48**	30**	46**	34**	33**	40**	53**	37**	42**	39**	36**	56**	39**	3.12	.78	103	42**	41**
5 Nonverb. Sounds					—	52**	63**	41**	31*	38**	36*	40**	08	40**	37*	45**	32*	48**	57**	19*	40**	46**	3.39	.61	49	42**	50**
6 Analyze Info.						—	48**	58**	62**	35**	63**	61**	65**	60**	44**	63**	56**	59**	53**	51**	58**	64**	3.08	.84	67	53**	54**
7 Comp. Info.							—	28*	58**	40**	34**	36**	19*	29**	46**	66**	32**	25*	50**	15	35**	44**	3.05	.79	77	38*	44**
8 Nonprec. Tools								—	80**	-09	55**	56**	61**	38**	56**	33*	63**	66**	65**	46**	28*	58**	3.45	.74	56	48**	41**
9 Prec. Tools									—	38**	50**	60**	66**	37*	46**	59**	65**	67**	64**	54**	66**	67**	3.23	.88	48	50**	48**
10 Opr. Kybd. Device										—	-06	27*	00	60**	33*	62**	55**	28*	50**	54**	31*	37**	3.31	.86	55	42**	45**
11 Adjust Equip.											—	68**	55**	68**	55**	69**	58**	53**	65**	58**	28*	52**	3.23	.82	57	52**	49**
12 Assemble/ Disassemble												-	59**	20	51**	59**	57**	55**	48**	64**	62**	73**	3.28	.82	53	46**	59**
13 Hand-arm Coord.													—	54**	43**	52**	61**	44**	56**	44**	47**	41**	3.37	.64	49	47**	47**
14 Hand-ear Coord.														—	47**	66**	42**	50**	63**	44**	32*	33**	3.21	.75	42	46**	61**
15 Influence Others															—	66**	33**	38**	49**	53**	42**	43**	2.85	.98	74	52**	39**
16 Routine Info.																—	47**	45**	58**	45**	55**	57**	3.22	.93	85	50**	57**
17 Good Precision																	—	69**	73**	57**	57**	61**	3.22	.83	87	51**	61**
18 Attn. Details																		—	55**	43**	53**	59**	3.21	1.38	107	55**	60**
19 Vigil																			—	49**	53**	58**	3.35	.79	63	46**	60**
20 Cope Time																				—	61**	60**	3.15	.84	92	46**	59**
21 Work Dist.																					—	54**	3.05	.82	87	53**	55**
22 Up-to-date																						—	3.10	.85	97	48**	65**

Note. Decimal points have been omitted from correlation coefficients.

*$p < .05$.
**$p < .01$.

2. Generally, the operational tests were better for predicting performance in apprenticeship ratings, and the experimental tests were better for predicting performance in technical ratings.

3. When multiple regressions were run for the global marks, experimental variables added substantially to the maximum validities of the classification tests. Increases in the shrunken validity coefficients were particularly high for the three technical ratings.

4. Movement Detection and Dealing with Concepts/Information were the most promising attributes for computerized measurement.

Prediction of Performance on Job Elements

1. The job elements which were most highly predictable were those which were obviously important and central to the duties of particular ratings. Thus, for PNs these job elements were Writing, Verbal Communication, Influencing Others, and Communicating Routine Information; for STs, Visual Display was highly predictable.

2. Operational variables were most effective for predicting on-job performance of UAs. The significant zero-order correlations of test scores with performance on job elements for UAs were apparently a result of the strong "g" factor in the operational variables. In the technical ratings, the most effective predictors for job elements were experimental tests. The best and most consistent of these were computerized measures.

3. There was little or no evidence of consistency of job element characteristics across ratings. The variables having significant zero-order validities for a job element in one rating in general did not have significant validities for the same element in other ratings.

4. Halo effect was not eliminated by using job element marks.

Predictability of Global Marks From Job Element Marks

In the technical ratings, slight increases in the accuracy of predicting global marks from job element marks were associated with the use of Time Required and Importance variables as moderators. However, the increases seemed to result from capitalization on chance relationships.

Accuracy of Expert Judgments of the Personal Attribute Requirements for Performance of Particular Job Elements

Generally low correlations were found between empirically-derived estimates of importance of personal attributes for particular job elements and similar estimates based on the judgments of personnel experts. Correlations of these estimates were statistically significant for only two of the 25 personal attribute/job element linkages. Estimates for Short-term Memory were the most accurate, and those for Dealing with Concepts/Information were accurate for some ratings and inaccurate for others.

These findings strongly imply that personnel experts cannot make accurate determinations of attribute requirements for job elements in the abstract. Whether or not they can make these determinations for positions with which they have first-hand familiarity remains to be seen.

Comparisons of the Predictive Accuracy of Synthetic-validity and Multiple-regression Techniques

Synthetic validity was generally not as accurate as multiple regression for predicting job performance. A major reason for the low accuracy of the synthetic-validity technique was the large halo effect in the data.

RECOMMENDATIONS

1. Since measures of Closure had significant relationships to the job performance of personnel in all four ratings/rating groups and had both positive and negative beta weights, a Closure test would appear to be highly suitable for a battery designed to predict on-job performance. A measure of Closure should be included in any classification battery designed to predict supervisory ratings of on-job performance, At present, a paper-and-pencil test of Closure would be just as effective as a computerized one, and would be less expensive to administer.

2. Skills in visual processing and interpretation, in addition to those measured by the operational classification tests, appear to be very important for on-job performance of STs. In the present research, measurement of these skills by computerized tests resulted

in increases of predictability substantial enough to provide practical improvement in the selection of STs. However, the findings should be replicated on a sample of at least 100, and preferably 200, STs.

The operational implementation of computerized selection testing will depend on the magnitude of the tradeoff between the improvements in predictability and the cost increases associated with computerized testing. Information from an additional study is required to accurately evaluate these qualities.

3. The research should be extended to investigate whether increases in validities can be achieved in any other rating (such as Operations Specialist) where interpretation of visual displays on screens and scopes is important.

4. Since marks for only one-thirteenth of the personal attributes described by Mecham and McCormick were examined in the present research, it is unlikely that all of the attributes which are important for on-job performance were included in the study. The substantial improvements in predictability found from the present relatively restricted sampling suggest that the present attributes, or others which have been defined, may provide useful selectors for ratings which are not now being accurately predicted. In this effort, the Mecham and McCormick study could serve as a useful guide for selecting personal attributes which would be appropriate for the major job elements of the ratings.

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APPENDIX

POSITION ANALYSIS QUESTIONNAIRE (PAQ)

DIRECTIONS

Your help is needed for a research project involving the performance of enlisted Navy personnel. This questionnaire is the last step in the evaluation of an extensive series of tests which were given to only a small number of men, so it is most important that you complete it. The questionnaire contains items to be used to describe the job held by the person whose name is in the upper left corner of this page. This information is to be used for RESEARCH PURPOSES ONLY, and will not affect any individual involved in this study.

Please complete the questionnaire carefully as follows:

1. Using the first column on the right (T), give the approximate percentage of time spent on every element included in the man's job. Many of the elements in the questionnaire will not be included in the man's job and you should put a dash (-) next to those elements.

2. In the second column (I), rate the importance of each element included in the man's job to overall job performance.

3. In the last column (P), rate his overall job performance on each element in his job.

It is important that all questions be answered carefully. Be sure to rate this man for every element which is part of his job. Each job element describes some general work activity, work condition, or job characteristic. In most cases examples are given to illustrate the "central idea" of the job element. However, these examples are intended only to help illustrate the idea and include only a few of the possible examples that could characterize the job element.

EXAMPLES:

Code	Amount of Time (T)
—	Does not apply (or is very incidental)
1	Under 1/10 of the time
2	Between 1/10 and 1/3 of the time
3	Between 1/3 and 2/3 of the time
4	Over 2/3 of the time
5	Almost continually

Code	Importance to This Job (I)
—	Does not apply
1	Very minor
2	Low
3	Average
4	High
5	Extreme

Compared to other men of the same pay grade, how would you rank this man in the performance of this task? (P)	
—	Does not apply
1	Lowest 5%
2	Next Lowest 25%
3	Middle 40%
4	Next Highest 25%
5	Highest 5%

ELEMENTS	RATINGS
A. Estimating the size of objects without direct measurement.	T — I — P —
B. Writing or dictating letters, reports, instructions, technical manuals, etc.	T 2 I 3 P 3

EXPLANATION: The man's job does not contain the activity in Example A, so dashes are used. In Example B, he does, however, write letters and reports between 1/10 and 1/3 of the time. They are of average importance to his job, and he prepares them as well as the middle 40% of personnel in his rate.

Code	Amount of Time (T)
—	Does not apply (or is very incidental)
1	Under 1/10 of the time
2	Between 1/10 and 1/3 of the time
3	Between 1/3 and 2/3 of the time
4	Over 2/3 of the time
5	Almost continually

Code	Importance to This Job (I)
—	Does not apply
1	Very minor
2	Low
3	Average
4	High
5	Extreme

Compared to other men of the same pay grade, how would you rank this man in the performance of this task? (P)	
—	Does not apply
1	Lowest 5%
2	Next Lowest 25%
3	Middle 40%
4	Next Highest 25%
5	Highest 5%

A. SOURCES OF JOB INFORMATION

Rate each of the following sources of job information in terms of amount of time spent using it, its importance to the job, and this person's proficiency in its use.

T___ I___ P___ 1. Written materials (manuals, reports, office notes, job instructions, notices and other written instructions.)

T___ I___ P___ 2. Pictorial materials (pictures or picture-like materials used as sources of information, for example, drawings, blueprints, diagrams, maps, tracings, photographic films)

T___ I___ P___ 3. Visual displays (dials, gauges, signal lights, radar/sonar scopes, clocks, etc.)

T___ I___ P___ 4. Features of nature (ocean surface conditions, geological samples, underwater topography, cloud formations, and other features of nature which are observed or inspected to provide information)

T___ I___ P___ 5. Behavior (observing the actions of people; for example, in teaching, supervising or counseling, where this behavior is a source of job information)

T___ I___ P___ 6. Spoken verbal sources (verbal instructions, orders, requests, conversations, interviews, discussions, formal meetings; consider only verbal communication which is relevant to job performance)

T___ I___ P___ 7. Non-verbal sounds (for example, noises, engine sounds, sonar, whistles, signals, horns)

8. Depth perception (judging the distance from the observer to the objects, or the distances between objects as they are positioned in space, as in operating a dentist's drill, handling and positioning objects, etc.) T___ I___ P___

9. Sound pattern recognition (recognizing different patterns, or sequences of sounds; for example, those involved in Morse Code, heart beats, engines not functioning correctly) T___ I___ P___

B. ESTIMATING ACTIVITIES

In this section are various operations involving estimation or judging activities. In each item consider activities in which the worker uses any or all of the senses; for example, sight, hearing, touch.

10. Estimating speed of moving objects (estimating the speed of moving objects or materials relative to a fixed point or to other moving objects; for example, the speed of vehicles materials on a conveyor belt, relative speed of other ships) T___ I___ P___

11. Estimating speed of processes (estimating the speed of on-going processes or a series of events while they are taking place; for example, assembly operations, charging batteries, preparation of records and reports to meet deadlines) T___ I___ P___

12. Inspecting (inspecting products, objects, materials, etc., either one's own workmanship or that of others, in terms of established standards; for example, identifying defects, classifying by grade) T___ I___ P___

Code	Amount of Time (T)
—	Does not apply (or is very incidental)
1	Under 1/10 of the time
2	Between 1/10 and 1/3 of the time
3	Between 1/3 and 2/3 of the time
4	Over 2/3 of the time
5	Almost continually

Code	Importance to This Job (I)
—	Does not apply
1	Very minor
2	Low
3	Average
4	High
5	Extreme

Compared to other men of the same pay grade, how would you rank this man in the performance of this task? (P)	
—	Does not apply
1	Lowest 5%
2	Next Lowest 25%
3	Middle 40%
4	Next Highest 25%
5	Highest 5%

13. Estimating size (estimating the dimensions of objects without direct measurement, including length, thickness, etc; for example, estimating the physical size of a sonar contact) T___ I___ P___

14. Estimating time (estimating the time required for past or future events or work activities; for example, judging the amount of time to make a delivery, estimating the time required to service a worn machine part or piece of equipment) T___ I___ P___

C. INFORMATION PROCESSING ACTIVITIES

In this section are various human operations involving the "processing" of information or data. Rate each item on all three scales.

15. Analyzing information or data (for the purpose of identifying underlying principles or facts by breaking down information into component parts; for example, interpreting reports or diagnosing mechanical disorders) T___ I___ P___

16. Compiling (gathering, grouping, classifying, or in some other way arranging information or data in some meaningful order or form; for example, preparing reports of various kinds, filing correspondence on the basis of content, selecting particular data to be gathered) T___ I___ P___

17. Coding/decoding (coding information or converting coded information back to its original form; for example, "reading" Morse Code, translating foreign languages, or using other coding systems such as shorthand, mathematical symbols, computer languages, drafting symbols, stock catalog numbers) T___ I___ P___

D. WORK OUTPUT

Use of devices and equipment. Consider in this category those powered devices which are used to move or modify work pieces, materials, products, or objects. They are manually controlled or directed devices using an energy source such as electricity, compressed air, fuel, hydraulic fluid, etc., in which the component part which accomplishes the modification is hand-held; such as a dentist's drill, welding equipment.

18. Non-precision tools/instruments (tools or instruments powered by the user to perform operations not requiring great accuracy or precision; for example, hammers, wrenches, trowels, knives, scissors, chisels, putty knives, strainers, hand grease guns; do not include long-handle tools here) T___ I___ P___

19. Precision tools/instruments hand-held powered tools or instruments used to perform operations requiring great accuracy or precision, dentist's drills, soldering irons, welding equipment, saws, used for especially accurate or fine work) T___ I___ P___

20. Drawing and related devices (instruments or devices used in plotting, sketching, illustrating, drafting; for example, pens, pencils, drawing instruments, drafting equipment; do not include measuring instruments here) T___ I___ P___

21. Keyboard devices (typewriters, adding machines, calculators, keypunch machines) T___ I___ P___

22. Hand-operated controls (controls operated by hand or arm for making frequent, but not continuous, adjustments; for example, hand controls on a crane or bulldozer, helm of ship) T___ I___ P___

Code	Amount of Time (T)
—	Does not apply (or is very incidental)
1	Under 1/10 of the time
2	Between 1/10 and 1/3 of the time
3	Between 1/3 and 2/3 of the time
4	Over 2/3 of the time
5	Almost continually

Code	Importance to This Job (I)
—	Does not apply
1	Very minor
2	Low
3	Average
4	High
5	Extreme

Compared to other men of the same pay grade, how would you rank this man in the performance of this task? (P)	
—	Does not apply
1	Lowest 5%
2	Next Lowest 25%
3	Middle 40%
4	Next Highest 25%
5	Highest 5%

T___ I___ P___ 23. Setting up/adjusting (adjusting, calibrating, aligning and/or setting up of machines or equipment; for example, setting up a lathe or drill press, adjusting an engine carburetor, adjusting, calibrating, and aligning electric circuitry)

T___ I___ P___ 24. Assembling/disassembling (either manually or with the use of hand tools putting parts of components together to form more complete items, or taking apart or disassembling items into their component parts)

T___ I___ P___ 25. Finger manipulation (making careful finger movements in various types of activities; for example, fine assembly, use of precision tools, repairing watches, use of writing and drawing instruments, operating keyboard devices; usually the hand and arm are not involved to any great extent)

T___ I___ P___ 26. Hand-arm manipulation (the manual control, or manipulation of objects through hand and/or arm movements, which may or may not require continuous visual control; for example, repairing automobiles)

T___ I___ P___ 27. Limb movement without visual control (movement of arms or legs from one position to another without the use of vision; for example, reaching for controls without looking, playing a musical instrument, touch typing)

T___ I___ P___ 28. Hand-ear coordination (the coordination of hand movement with sounds or instructions that are heard; for example, tuning radio receivers, adjusting sonar equipment)

E. COMMUNICATION WITH OTHER PERSONS

This section deals with different aspects of interactions between people involved in various kinds of work.

29. Persuading (dealing with others in order to influence them toward some action or point of view) T___ I___ P___

30. Instructing (the teaching of knowledge or skills, either in an informal or formal manner, to others; for example, an A-School instructor, a journeyman teaching an apprentice) T___ I___ P___

31. Interviewing (conducting interviews directed toward some specific objective; for example, interviewing for job assignments) T___ I___ P___

32. Routine information exchange (the giving and/or receiving of information of a routine or simple nature; for example, receptionist, information counter clerk) T___ I___ P___

33. Writing (for example, writing or dictating letters, reports, instructions, technical manuals) T___ I___ P___

F. TYPES OF JOB-REQUIRED PERSONAL CONTACT

This section lists types of individuals with whom the man must have personal contact in order to perform his job. Consider personal contact not only with personnel within the command but also with personnel from other commands, if contact with them is part of the job.

34. Supervisors (those personnel who have immediate responsibility for a work group; for example, Division Chief Petty Officers, office managers) T___ I___ P___

35. Clients, counselees, trainees T___ I___ P___

Code	Amount of Time (T)
—	Does not apply (or is very incidental)
1	Under 1/10 of the time
2	Between 1/10 and 1/3 of the time
3	Between 1/3 and 2/3 of the time
4	Over 2/3 of the time
5	Almost continually

Code	Importance to This Job (I)
—	Does not apply
1	Very minor
2	Low
3	Average
4	High
5	Extreme

Compared to other men of the same pay grade, how would you rank this man in the performance of this task? (P)	
—	Does not apply
1	Lowest 5%
2	Next Lowest 25%
3	Middle 40%
4	Next Highest 25%
5	Highest 5%

T___ I___ P___ 36. Frustrating situations (job situations in which attempts to deal with problems or to achieve job objects are obstructed or hindered, and may thus contribute to frustration on the part of the worker)

G. JOB DEMANDS

This section lists various types of demands that the job situation may impose upon the worker, usually requiring that he adapt to these in order to perform his work satisfactorily.

T___ I___ P___ 37. Precision (need to be more than normally precise and accurate)

T___ I___ P___ 38. Attention to detail (need to give careful attention to various details of one's work, being sure that nothing is left undone)

T___ I___ P___ 39. Vigilance: continually changing events (need to be continually aware of variations in a continually or frequently changing situation; for example, continually watching frequently changing dials, driving in traffic, controlling aircraft traffic)

T___ I___ P___ 40. Time pressure of situation (urgent time deadlines, rush jobs)

T___ I___ P___ 41. Working under distractions (telephone calls, interruptions, disturbances from others)

T___ I___ P___ 42. Updating job knowledge (keeping job knowledge current, being informed of new developments related to the job)

H. OVERALL PERFORMANCE EVALUATION

43. Considering all aspects of the job, how good is this man's performance?

(1) Lowest 5%
(2) Next lowest 10%
(3) Next lowest 15%
(4) Middle 40%
(5) Next highest 15%
(6) Next highest 10%
(7) Highest 5%

T___ I___ P___

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